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ABSTRACT

This learning module, one in a series of 20 related training modules for apprentice stationary engineers, deals with miscellaneous job skills needed by persons working in power plants. Addressed in the individual instructional packages included in the module are the following topics: transformers, circuit protection, construction of foundations for and installation of industrial equipment, and trade terms. Each instructional package in the module contains some or all of the following: a lesson goal, performance indicators, a study guide, a vocabulary list, an introduction, instructional text, an assignment, a job sheet, a self-assessment activity, a post-assessment instrument, answers to the post-assessment instrument, and a list of recommended supplementary references. (MN)

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APPRENTICESHIP

STATIONARY ENGINEERS

RELATED TRAINING MODULES

20.1-23.1 MISCELLANEOUS

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APPRENTICESHIP

STATIONARY ENGINEERS
RELATED TRAINING MODULES

COMPUTERS

1.1 Digital Language
1.2 Digital Logic
1.3 Computer Overview
1.4 Computer Software

SAFETY

2.1 General Safety
2.2 Hand Tool Safety
2.3 Power Tool Safety
2.4 Fire Safety
2.5 Hygiene Safety
2.6 Safety and Electricity

DRAWING

3.1 Types of Drawings and Views
3.2 Blueprint Reading/Working Drawings
3.3 Scaling and Dimensioning
3.4 Machine and Welding Symbols

TOOLS

4.1 Measuring, Layout and Leveling Tools
4.2 Boring and Drilling Tools
4.3 Cutting Tools, Files and Abrasive
4.4 Holding and Fastening Tools
4.5 Fastening Devices

ELECTRICITY/ELECTRONICS

5.1 Basics of Energy
5.2 Atomic Theory
5.3 Electrical Conduction
5.4 Basics of Direct Current
5.5 Introduction to Circuits
5.6 Reading Scales
5.7 Using a V.O.M.
5.8 OHM'S Law
5.9 Power and Watt's Law
5.10 Kirchoff's Current Law
5.11 Kirchoff's Voltage Law
5.12 Series Resistive Circuits
5.13 Parallel Resistive Circuits
5.14 Series - Parallel Resistive Circuits

5.15 Switches and Relays
5.16 Basics of Alternating Currents
5.17 Magnetism

HUMAN RELATIONS

6.1 Communications Skills
6.2 Feedback
6.3 Individual Strengths
6.4 Interpersonal Conflicts
6.5 Group Problem Solving, Goal-setting and Decision-making
6.6 Worksite Visits
6.7 Resumes
6.8 Interviews
6.9 Work Habits and Attitudes
6.10 Wider Influences and Responsibilities
6.11 Personal Finance
6.12 Expectations

TRADE MATH

7.1 Linear - Measure
7.2 Whole Numbers
7.3 Addition and Subtraction of Common Fraction and Mixed Numbers
7.4 Multiplication and Division of Common Fractions and Whole and Mixed Numbers
7.5 Compound Numbers
7.6 Percent
7.7 Mathematical Formulae
7.8 Ratio and Proportion
7.9 Perimeters, Areas and Volumes
7.10 Circumference and Wide Area of Circles
7.11 Area of Planes, Figures, and Volumes of Solid Figures
7.12 Graphs
7.13 Basic Trigonometry
7.14 Metrics

HYDRAULICS

8.1 Hydraulics - Lever
8.2 Hydraulics - Transmission of Force
8.3 Hydraulics - Symbols
8.4 Hydraulics - Basic Systems
8.5 Hydraulics - Pumps
8.6 Hydraulics - Pressure Relief Valve
8.7 Hydraulics - Reservoirs
8.8 Hydraulics - Directional Control Valve
8.9 Hydraulics - Cylinders
8.10 Hydraulics - Forces, Area, Pressure
8.11 Hydraulics - Conductors and Connectors
8.12 Hydraulics - Troubleshooting
8.13 Hydraulics - Maintenance

REFRIGERATION

9.1 Refrigeration - Introduction
9.2 Refrigeration - Compressors
9.3 Refrigeration - Temperature Controls
9.4 Refrigeration - Condensers and Evaporation
9.5 Refrigeration - Purge, Evacuate, Recharge
9.6 Refrigeration - Troubleshooting

MACHINE COMPONENTS

10.1 Machine Components - Shafts
10.2 Machine Components - Bearings
10.3 Machine Components - Seals and Gaskets
10.4 Machine Components - Chain Shafts
10.5 Machine Components - Belts and Pulleys

LUBRICATION

11.1 Lubrication - Introduction
11.2 Lubrication - Standards and Selection of Lubricants

BOILERS

12.1 Boilers - Fire Tube Types
12.2 Boilers - Watertube Types
12.3 Boilers - Construction
12.4 Boilers - Fittings
12.5 Boilers - Operation
12.6 Boilers - Cleaning
12.7 Boilers - Heat Recovery Systems
12.8 Boilers - Instruments and Controls
12.9 Boilers - Piping and Steam Traps

PUMPS

13.1 Pumps - Types and Classification
13.2 Pumps - Applications
13.3 Pumps - Construction
13.4 Pumps - Calculating Heat and Flow
13.5 Pumps - Operation
13.6 Pumps - Monitoring and Troubleshooting
13.7 Pumps - Maintenance

STEAM

14.1 Steam - Formation and Evaporation
14.2 Steam - Types
14.3 Steam - Transport
14.4 Steam - Purification

TURBINES

15.1 Steam Turbines - Types
15.2 Steam Turbines - Components

15.3 Steam Turbines - Auxillaries
15.4 Steam Turbines - Operation and Maintenance
15.5 Gas Turbines

COMBUSTION

16.1 Combustion - Process
16.2 Combustion - Types of Fuel
16.3 Combustion - Air and Fuel Gases
16.4 Combustion - Heat Transfer
16.5 Combustion - Wood

FEEDWATER

17.1 Feedwater - Types and Equipment
17.2 Feedwater - Water Treatments
17.3 Feedwater - Testing

GENERATORS

18.1 Generators - Types and Construction
18.2 Generators - Operation

AIR COMPRESSORS

19.1 Air Compressors - Types
19.2 Air Compressors - Operation and Maintenance

MISCELLANEOUS

20.1 Transformers
21.1 Circuit Protection
22.1 Installation - Foundations
22.2 Installation - Alignment
25.1 Trade Terms

STATIONARY ENGINEER
SUPPLEMENTARY REFERENCE DIRECTORY

Note: All reference packets are numbered on the upper right-hand corner of the respective cover page.

Supplementary Packet #	Description	Related Training Module
12.1	Correspondence Course, Lecture 1, Sec. 2, Steam Generators, Types of Boilers I, S.A.I.T., Calgary, Alberta, Canada	12.1 Boilers, Fire Tube Type
12.2	Correspondence Course, Lecture 2, Sec. 2, Steam Generators, Types of Boilers II, S.A.I.T., Calgary, Alberta, Canada	12.2 Boilers, Water Tube Type
12.3	Correspondence Course, Lecture 2, Sec. 2, Steam Generators, Boiler Construction & Erection, S.A.I.T., Calgary, Alberta, Canada	12.3 Boilers, Construction
12.4	Correspondence Course, Lecture 4, Sec. 2, Steam Generators, Boiler Fittings II, S.A.I.T., Calgary, Alberta, Canada	12.4 Boilers, Fittings
12.4	Corresondence Course, Lecture 4, Sec. 2, Steam Generators, Boiler Fitting I, S.A.I.T., Calgary, Alberta, Canada	12.4 Boilers, Fittings
12.5	Correspondence Course, Lecture 10, Sec. 2, Steam Generation, Boiler Operation, Maintenance, Inspection, S.A.I.T., Calgary, Alberta, Canada	12.5 Boilers, Operation
12.7	Correspondence Course, Lecture 3, Sec. 2, Steam Generation, Boiler Details, S.A.I.T., Calgary, Alberta, Canada	12.7 Boilers Heat Recovery Systems
12.8	Refer to reference packet 14.3/12.8	
		PUMPS
13.1	Correspondence Course, Lecture 9, Sec. 2, Steam Generator, Power Plant Pumps, S.A.I.T., Calgary, Alberta, Canada	13.1 Types & Classification
13.2		13.2 Applications
13.4		13.4 Calculating Heat & Flow
13.6		13.6 Monitoring & Troubleshooting
13.7		13.7 Maintenance
13.3	Correspondence Course, Lecture 6, Sec. 3, Steam Generators, Pumps, S.A.I.T., Calgary, Alberta, Canada	13.3 Construction
13.5		13.5 Operation

Supplementary Packet #	Description	Related Training Module
14.3 12.8	Correspondence Course, Lecture 6, Section 3, Steam Generators, Steam Generator Controls, S.A.I.T., Calgary, Alberta, Canada	14.3 Steam, Transport 12.8 Boilers, Instruments & Controls
14.4	Correspondence Course, Lecture 11, Section 2, Steam Generators, Piping II, S.A.I.T., Calgary, Alberta, Canada	14.4 Steam, Purification
15.1	Correspondence Course, Lecture 1, Sec. 4, Prime Movers & Auxiliaries, Steam Turbines, S.A.I.T., Calgary, Alberta, Canada	15.1 Steam Turbines, Types
15.2	Correspondence Course, Lecture 4, Sec. 3, Prime Movers, Steam Turbines I, S.A.I.T., Calgary, Alberta, Canada	15.2 Steam Turbines, Components
15.3	Correspondence Course, Lecture 2, Sec. 4, Prime Movers & Auxiliaries, Steam Turbine Auxiliaries, S.A.I.T., Calgary, Alberta, Canada	15.3 Steam Turbines, Auxiliaries
15.4	Correspondence Course, Lecture 6, Sec. 3, Prime Movers, Steam Turbine Operation & Maintenance, S.A.I.T., Calgary, Alberta, Canada	15.4 Steam Turbines, Operation & Maintenance
15.5	Correspondence Course, Lecture 8, Sec. 3, Prime Movers, Gas Turbines, S.A.I.T., Calgary, Alberta, Canada	15.5 Gas Turbines
16.2	Boilers Fired with Wood and Bark Residues, D.D. Junge, F.R.L., O.S.U. 1975	16.2 Combustion Types of Fuel
16.2	Correspondence Course, Lecture 5, Sec. 2, Steam Generators, Fuel Combustion, S.A.I.T., Calgary, Alberta, Canada	16.2 Combustion Types of Fuel
16.3	Correspondence Course, Lecture 5, Sec. 2, Plant Services, Fuel & Combustion, S.A.I.T., Calgary, Alberta, Canada	16.3 Combustion, Air & Fuel Gases
17.1	Correspondence Course, Lecture 12, Sec. 3, Steam Generation, Water Treatment, S.A.I.T., Calgary, Alberta, Canada	17.1 Feed Water, Types & Operation
17.2	Correspondence Course, Lecture 12, Sec. 2, Steam Generation, Water Treatment, S.A.I.T., Calgary, Alberta, Canada	17.2 Feed Water, Water Treatments

Supplementary Packet #	Description	Related Training Module
17.3	Correspondence Course, Lecture 7, Sec. 2, Steam Generators, Boiler Feed Water Treatment, S.A.I.T., Calgary, Alberta, Canada	17.3 Feed Water, Testing
18.1	Correspondence Course, Lecture 2, Sec. 5, Electricity, Direct Current Machines, S.A.I.T., Calgary, Alberta, Canada	18.1 Generators, Types & Construction
18.1 18.2	Correspondence Course, Lecture 4, Sec. 5, Electricity, Alternating Current Generators, S.A.I.T., Calgary, Alberta, Canada	18.1 Generators, Types & Construction 18.2 Generators, Operation
19.1	Corrspondence Course, Lecture 5, Sec. 4, Prime Movers & Auxiliaries, Air Compressor I, S.A.I.T., Calgary, Alberta, Canada	19.1 Air Compressors, Types
19.1 19.2	Correspondence Course, Lecture 6, Sec. 4, Prime Movers & Auxiliaries, Air Compressors II, S.A.I.T., Calgary, Alberta, Canada	19.1 Air Compressors, Types 19.2 Air Compressors, Operation & Maintenance
20.1	Basic Electronics, Power Transformers, EL-BE-51	20.1 Transformers
21.1	Correspondence Course, Lecture 7, Sec. 5, Electricity, Switchgear & Circuit, Protective Equipment, S.A.I.T., Calgary, Alberta, Canada	21.1 Circuit Protection
22.1	Correspondence Course, Lecture 10, Sec. 3, Prime Movers, Power Plant Erection & Installation, S.A.I.T., Calgary, Alberta, Canada	22.1 Installation Foundations

RECOMMENDATIONS FOR USING TRAINING MODULES

The following pages list modules and their corresponding numbers for this particular apprenticeship trade. As related training classroom hours vary for different reasons throughout the state, we recommend that the individual apprenticeship committees divide the total packets to fit their individual class schedules.

There are over 130 modules available. Apprentices can complete the whole set by the end of their indentured apprenticeships. Some apprentices may already have knowledge and skills that are covered in particular modules. In those cases, perhaps credit could be granted for those subjects, allowing apprentcies to advance to the remaining modules.

We suggest the the apprenticeship instructors assign the modules in numerical order to make this learning tool most effective.

SUPPLEMENTARY INFORMATION

ON CASSETTE TAPES

Tape 1: Fire Tube Boilers - Water Tube Boilers and Boiler Manholes and Safety Precautions

Tape 2: Boiler Fittings, Valves, Injectors, Pumps and Steam Traps

Tape 3: Combustion, Boiler Care and Heat Transfer and Feed Water Types

Tape 4: Boiler Safety and Steam Turbines

NOTE: The above cassette tapes are intended as additional reference material for the respective modules, as indicated, and not designated as a required assignment.

20.1

TRANSFORMERS

Goal:

The apprentice will be able to describe types and applications of transformers.

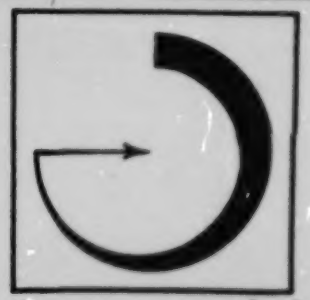
Performance Indicators:

1. Describe step-up and step-down transformers.
2. Describe turns ratio of transformers.
3. Describe shell type and core type transformers.
4. Describe construction of transformers.
5. Describe cooling of transformers.
6. Describe protection of transformers.
7. Describe paralleling of transformers.
8. Describe rating of transformers.
9. Describe loading of transformers.

Study Guide

* Read the goal and performance indicators to find what is to be learned from package.
* Read the vocabulary list to find new words that will be used in package.
* Read the introduction and information sheet.
* Complete the job sheet.
* Complete self-assessment.
* Complete post-assessment.

Vocabulary



* Askarel
* Buchholz gas detector relay
* Cooling tubes
* Copper losses
* Core type transformer
* Distribution transformer
* Eddy currents
* Hystersis
* Iron losses
* Kilovolt amperes kVA
* Laminated iron core
* Magnetic flux
* Open-circuit test
* Paralleling
* Power transformer
* Primary voltage
* Secondary coil
* Shell type transformer
* Short circuit test
* Step-down transformer
* Step-up transformer
* Turns ratio

Introduction

Electricity is usually generated and sent through transmission lines at high voltages. The voltage must be greatly reduced at the point of use of that electricity. The transformer is used to decrease or increase the voltage of electricity, depending on the need.

At the same time the voltage is changed, the amperage is also increased or decreased. If the voltage is increased by a transformer, the amperage is decreased. Voltage decreases result in amperage increases.

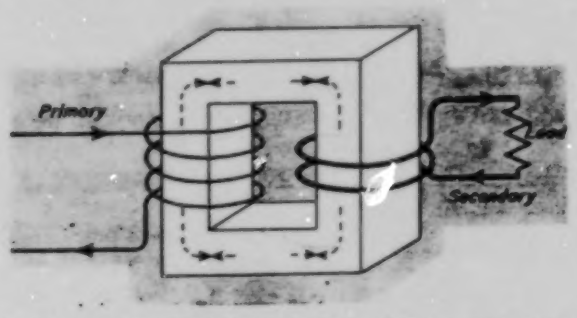
The transformer is widely used in equipment of high voltage and low voltage capacity. It allows electricity to be delivered at voltage levels that offer safe and efficient machine operation.

Information

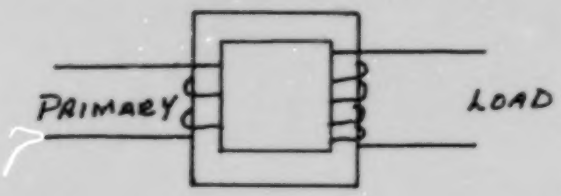
Transformers change the voltage of an electrical supply. Step-up transformers increase the voltages. Step-down transformers decrease the voltage. Those with an output greater than 500 kVA are called power transformers while those with less output are called distribution transformers. Another use of transformers is to change the phase of electricity.

Operation of Transformers

A transformer transfers energy by the use of magnetism. The primary voltage flowing into the transformer enters a wire coiled about a laminated iron core. This creates a field of magnetic flux which is transferred to the secondary-coil. The secondary coil is another wire coiled about the iron core. Electrical voltage is changed as it moves from the primary coil to the secondary coil. Whether the voltage is increased or decreased depends on the number of times the wire is coiled about the core. The coil ratio between the primary and secondary windings determine whether it is a step-up or step-down transformer.



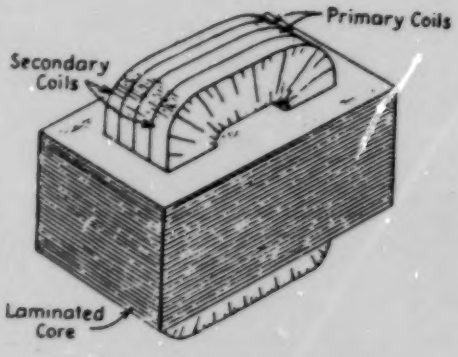
The ratio of the coil windings is called turns ratio. The turns ratio is equal to the number of turns (loops) or wire on one winding divided by the number of turns on the other winding. In the diagram above, the turns ratio is 2:1. This means that the voltage ratio is also 2:1. In this example, the primary is twice the voltage of the secondary which makes it a step-down transformer. A step-up transformer would appear as the following diagram.



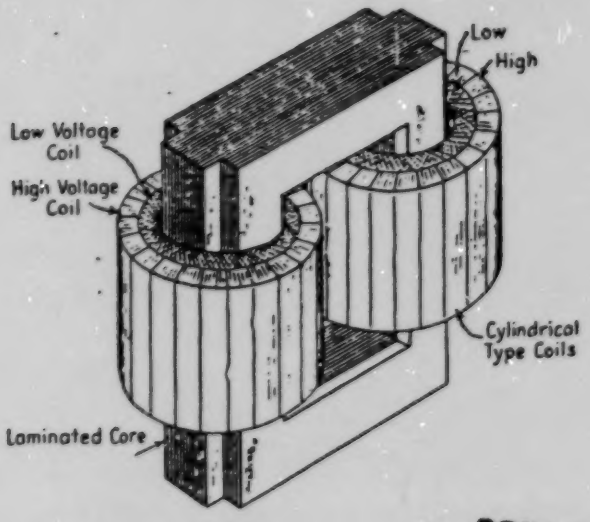
Information

Types of Transformers

Most transformers are of either shell type or core type. Many small transformers are of the shell type. In the shell type the laminated iron core surrounds the windings.



In the core type which is common with power transformers, the windings surround the laminated core.



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Information

Construction

The laminated core material is iron that has been cut into strips and laminated together in a circular cross-section. The windings are made of copper wire. The windings are separated from each other and the core material by insulation. The core size and copper wire size is determined by the density of the magnetic flux needed for a transformer rating. The core and coils are usually immersed in an oil filled case for cooling purposes.

Cooling

Some small rating transformers are cooled by air. Most use oil for insulation and cooling. A specially refined oil is used for this purpose. It is almost free of impurities and will flow at low temperatures. Large transformers have cooling tubes which may be banked as separate radiators using forced circulation of the oil.

Protection

Gas is formed when an electrical fault develops in the transformer. A build up of this gas results in an explosion. A gas detector relay should be used to detect the buildup of gas and prevent explosion damages. The Buchholz gas detector relay sounds an alarm when gas is building up in the transformer. A non-flammable insulating and cooling liquid, called Askarel, is often used instead of oil for increased fire protection.

Paralleling Transformers

Transformers can be hooked in parallel circuits if the voltage ratings are the same at the primary and secondary sides of the transformers. Also, the windings must be very much alike in regard to resistance, reactance and impedance. The polarity of the windings must be known before hooking transformers in parallel. The manufacturer usually marks the leads to allow parallel hookups to be easily made. The polarity of the transformers must be the same.

Transformer Ratings

Kilovolt amperes kVA are used to measure outputs of transformers. This measurement of the maximum current that the transformer can carry without exceeding a given rise in temperature is called the rating.

Information

Loading

Some losses in efficiency are directly related to loading of transformers. These efficiency losses are called copper losses. Iron losses due to hysterisis and eddy currents are constant for all loads. The laminations used in core construction reduce eddy current losses. Hysterisis can be reduced by using silicon steel in the core. Copper loss can be measured by a short circuit test in which the secondary winding is short-circuited and a reading (Watts) is made on the primary circuit. The open circuit test is used to measure iron losses.

Assignment

* Study the principles of transformers in any standard electricity textbook.
* Complete the job sheet.
* Complete the self-assessment and check answers.
* Complete the post-assessment and ask instructor to check answers.

Job Sheet

MEASURE RESISTANCE BETWEEN LEADS OF A TRANSFORMER

* Obtain an ohmmeter.
* Label each lead of transformer using masking tape. There are four leads.
* Record the measurements.

  1 to 2 _____

  1 to 3 _____

  1 to 4 _____

  2 to 3 _____

  2 to 4 _____

  3 to 4 _____

* The larger resistance will have the larger numer of turns.
* The larger number of turns is normally the primary winding.
* Which leads connect to the primary winding? _____
* Which leads connect to the secondary winding? _____

Self Assessment

1. Voltage is increased by use of a _____ transformer.

2. Voltage is decreased by use of a _____ transformer.

3. Transformers with output in excess of 500 kVA is called a _____ transformer.

4. Transformers transfer energy between the primary and secondary windings by the use of _____.

5. The primary winding has 25 loops of wire and the secondary has 5 loops. What is the turns ratio?

6. List two types of transformers based on their construction design.

7. Laminated core material is _____.

8. Winding material is _____.

9. A device to prevent explosions in transformers is called a gas _____ _____.

10. _____ is used in place of oil as a coolant because it offers more protection against fire.

Self Assessment Answers

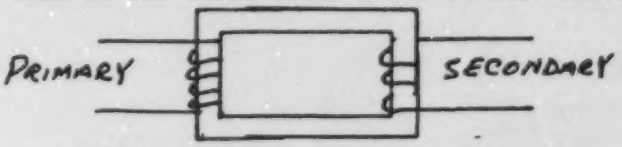
1. Step-up
2. Step-down
3. Power
4. Magnetism
5. 5:1
6. Shell, core
7. Iron
8. Copper
9. Gas detector relay
10. Askarel

Post Assessment

1. What is the purpose of using Askarel instead of oil as a coolant for transformers?

2. Why is a Buchholz gas detector relay needed on a transformer?

3. What is the turns ratio shown in the following sketch?



4. A transformer with less than 500 kVA output is called a _____ transformer.

5. What does kVA mean?

6. Iron losses are due to _____ and eddy currents.

7. Iron losses can be measured by a _____ _____ test.

8. The laminations of core material are necessary to control iron losses due to _____ _____.

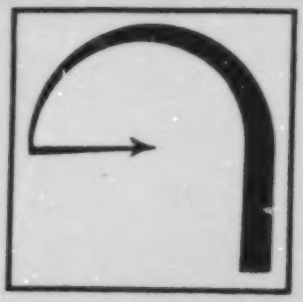
9. Can transformers of unlike polarity be paralleled?

10. In a _____ type transformer, the windings surround the laminated core.

Instructor Post Assessment Answers

1. Fire prevention
2. Prevent explosions from gas build up
3. 2:1
4. Distribution
5. Kilo volt-ampere
6. Hysterisis
7. Open circuit test
8. Eddy current
9. No
10. Core type

Supplementary References



* ILS Package EL-BE-51. Power Transformers. 1981.

21.1

CIRCUIT PROTECTION

Goal:

The apprentice will be able to describe devices used in protection of electrical circuits.

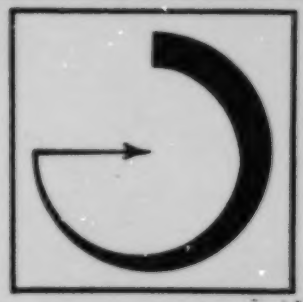
Performance Indicators:

1. Describe circuit breakers.
2. Describe switches.
3. Describe contactors.
4. Describe fuses.
5. Describe relays.

Study Guide

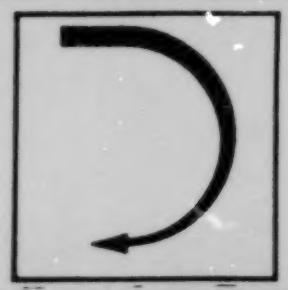
* Read the goal and performance indicators to find what is to be learned from package.
* Read the vocabulary list to find new words that will be used in package.
* Read the introduction and information sheet.
* Complete the job sheet.
* Complete self-assessment.
* Complete post-assessment.

Vocabulary



* Air blast
* Air break
* Arc chute
* Attracted armature relay
* Axial blast
* Balanced current
* Blow-out coil
* Cartridge fuse
* Contactors
* Cross blast
* Direct acting trip switch
* Directional relay
* Distance protection
* Double throw
* Explosion pot
* Fusible safety switch
* Induction coil relay
* Induction disc relay
* High voltage fuse
* Multi-break
* Oil immersed
* Plug fuse
* Relay
* Safety switch
* Single throw
* Thermal type relay
* Time-lag fuse
* Time-overcurrent relay
* Unit protection

Introduction



Equipment can be damaged when electrical current exceeds the load rating for which it was designed. Protective devices are used to shut off the circuit when it has a current overload.

A circuit breaker breaks the current between two contact points under short circuit or overload conditions.

Information

Circuit Breakers

Steam generation equipment uses circuit breakers of the following types:

1. Air break type
2. Oil immersed type
3. Air blast type

Breakers up to 575 volts are usually air break types. Those with ratings in excess of 575 volts are oil immersed and air blast circuit breakers.

Air Break Circuit Breaker

The lower voltage air break type uses a puff of air or an arc chute to control the arc. Arcing prevents a sudden surge of induced voltage at the moment the circuit is broken. Although the arc plays a needed part, it must be extinguished so that the switch will not be damaged.

Oil Immersed Circuit Breakers

The oil immersed circuit breaker uses oil to control the arc and to help cool the contacts. Oil serves as an insulator and helps cool the gases from arcing. Devices used in controlling the arc are called explosion pots. Many types of explosion pots are used:

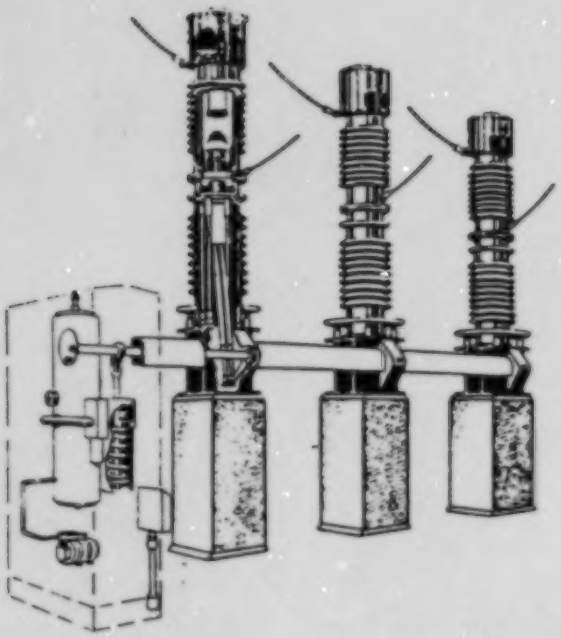
* Plain--has one fixed and one movable contact. The movable contact draws the arc.
* Double chamber--uses two chambers and the arc is swept from the upper chamber to vent.
* Magnetic inserts--extinguishes arc by pulling it into pools of cool oil.

The multi-break circuit breaker gives high speed interruption of the current by shunting each break with resistors. Oil immersed circuit breakers are divided into two groups:

* Low oil content breakers that use small quantities of oil.
* Bulk oil breakers that require large volumes of oil.

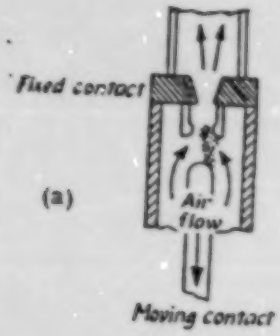
An oil immersed circuit breaker is shown on the next page.

Information



Air Blast Circuit Breaker

The air blast circuit breaker utilizes a blast of air to remove ionzied matter from between the contact points. High velocity air blasts extinguish the arc quickly. The two types of air blast circuit breakers are the axial blast and cross blast. The axial blast circuit breaker encloses the arc in the air stream and weakens it enough that the contacts can withstand the voltage. An axial blast circuit breaker is shown below:



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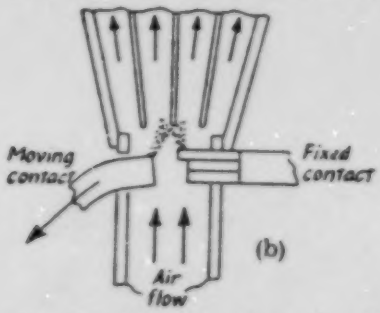
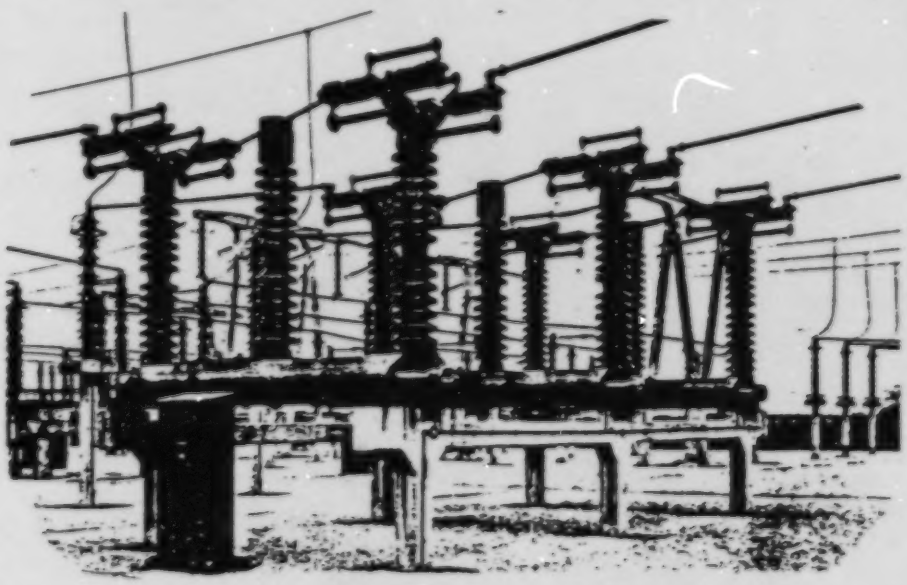
Information

The cross blast circuit breaker opens its main contacts wider than the axial blast type. A diagram of a cross blast type is shown in the following diagram.



An air blast circuit breaker is shown in the following photograph.



Switches

Switches are used to close off parts of electric circuits. A safety switch is enclosed in metal and operated by an outside lever. Usually a safety switch is used with fuses. When short circuits occur, the fuse blows. A fusible safety switch contains fuses. Switches may be obtained in single or double throw units. Safety switches are available in 230 and 575 volt ratings.

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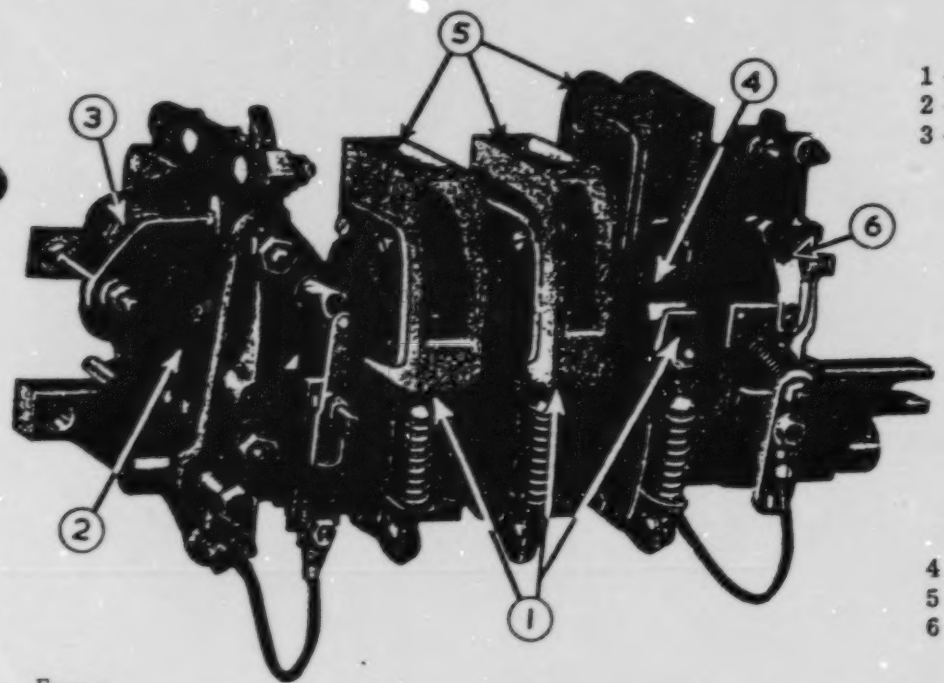
Information

Contactors

Magnetic contactors opens and closes circuits by a magnetic switch. These contactors are used for automatic starting and stopping of motors of less than 75 KW ratings. Contactors have a blow out coil that helps to extinguish the arc. Magnetic contactors are used on motors up to 75 KW.

Large AC contactors are switched on by an operating mechanism which is triggered by a solenoid coil. A triple-pole AC contactor is shown.



1 - Main Contacts
2 - Operating Mechanism
3 - Solenoid Coil

4 - Blow-out Coil
5 - Arc Shield
6 - Auxiliary Contacts

Fuses

Fuses can be obtained in many sizes and voltage ratings. They are the most simple form of circuit protection. The replacement costs of fuses is greater than other types of protection. A problem with "single" phasing occurs when only one fuse is blown. Fuses are appropriate to low voltage systems. Fuses may be purchased in plug, cartridge, time-lag and high voltage types. A time-lag fuse will tolerate excess voltage for a short period without blowing out.

Information

Trip Switches

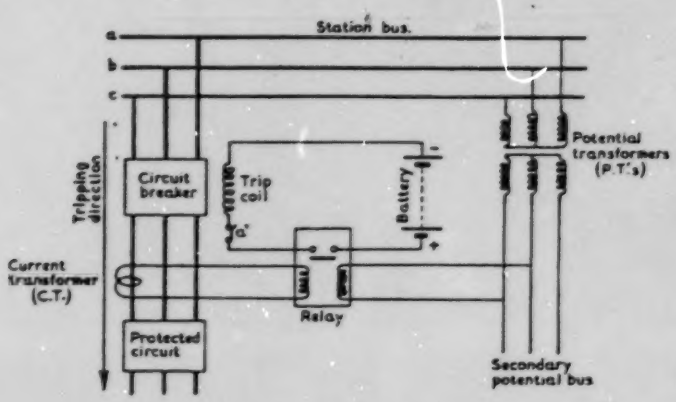
Direct acting trip switches operate off of a solenoid or bi-metallic element which trip the switch mechanically. Single phasing is not a problem because the switches are multi-pole units. Such trip switches are usually used on low voltage systems.

Relays

Relays are used to protect high voltage systems. These devices are called protective relays. Relays respond to changes in the electrical current and trip circuit breakers or other protection devices. The relay performs the selective function that determines when the breaker should be tripped. As protective devices, relays are more reliable in preventing damage to equipment by short circuit or overload conditions. Various types of relays are available and are designed to trip under a given set of conditions. Some trip when excessive current flows in either direction while others respond to one directional current. Relays may be classified as:

* Attracted armature relays
* Induction coil relays
* Induction disc relays
* Thermal type relays

The above relays are so named because of their parts and arrangement of parts within the relay system. There are too many types of relays to be described individually in this learning package. The basic connections of a protective relay are shown in the following diagram.



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Information

When one or more relays are used to protect a circuit, it is called a relay scheme. The common relay schemes are:

* Directional relays are used to protect equipment in which the current flows in one direction, i.e. generators. The relay contact points respond to current flowing in a direction other than the regular one.

* Time-overcurrent relaying is used on low-voltage systems. When one section of the electrical system is short circuited or overloaded, the current will flow in from the parts that do not have a problem. This keeps the overcurrent in the damaged area so that other sections are not affected.

* Unit protection relays compare current that enters and leaves a specific unit. This scheme protects against problems within the circuits of that unit.

* Distance protection relays are set to trip according to the length of line that the current travels through. It is based on the impedance of the line and its relationship to the amperage and voltage placed on the circuit.

* Balanced current relays operate in a comparison of parallel circuits of of equal impedance. Problems in one circuit will be detected by the difference between the two circuits.

Assignment

* Read pages 4 - 33 of reference and study diagrams.
* Complete the job sheet.
* Complete the self-assessment and check answers.
* Complete the post-assessment and ask the instructor to check answers.

Job Sheet

ANALYZE SPECIFICATIONS OF CIRCUIT BREAKERS

* Obtain manufacturers specifications for air break, air blast and oil immersed circuit breakers.

* Analyze

  - How is the arc controlled?
  - What special features exist for arc control?
  - What is the voltage rating?
  - What are the recommended applications for each type?

Self Assessment

1. Name three types of circuit breakers.

2. The _____ _____ type circuit breaker is used up to 575 volt ratings.

3. The _____ _____ type circuit breakers is used on systems with voltage greater than 575 volts.

4. The _____ _____ circuit breaker uses an arc chute or puff of air to control the arc.

5. The _____ _____ circuit breaker uses explosion pots to control the arc.

6. List two types of explosion pots.

7. List two major groups of oil immersed circuit breakers.

8. The _____ _____ circuit breaker uses high velocity blasts of air to extinguish the arc.

9. What is a safety switch with fuses called?

10. List two relay schemes.

Self Assessment Answers

1. Air break, air blast and oil immersed
2. Air break
3. Air blast or oil immersed
4. Air break
5. Oil immersed
6. Plain, double chamber, double break, magnetic inserts
7. Bulk oil, low oil
8. Air blast
9. Fusible safety switch
10. Directional, time-overcurrent, unit protection, distance protection, balanced current

Post Assessment

1. List two types of air blast circuit breakers.

2. A switch that is enclosed in metal and operated by an outside switch is a _____ _____.

3. A relay scheme that measures the differences between two parallel circuits of equal impedance is called a _____ _____ scheme.

4. A relay scheme that operates when current flows in an abnormal direction is called a _____ relay scheme.

5. Direct acting trip switches operate off of a _____ or bi-metallic element.

6. List four types of fuses.

7. A blow-out coil is part of a _____.

8. An oil immersed circuit breaker that uses small quantities of oil is called a _____ _____ breaker.

9. A circuit breaker that gives high speed interaction of current by shunting each break with resistors is called a _____ _____ circuit breaker.

10. Oil immersed circuit breakers control the arc by use of _____ _____.

Instructor Post Assessment Answers

1. Axial blast and cross blast
2. Safety switch
3. Balanced current
4. Directional
5. Salenoid
6. Plug, cartridge, time-lag, high voltage
7. Contactor
8. Low oil
9. Multi-break
10. Explosion pots

Supplementary References

* Correspondence Course. Lecture 7, Section 5. Electricity. Southern Alberta Institute of Technology. Calgary, Alberta, Canada.

22.1

INSTALLATION — FOUNDATIONS

Goal:

The apprentice will be able to describe foundations for mechine installation.

Performance Indicators:

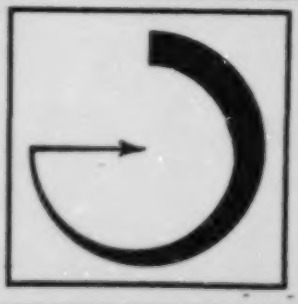
1. Describe test holes.
2. Describe foundation footings.
3. Describe machine foundations.
4. Describe concrete and concrete quality.
5. Describe curing of concrete.
6. Describe rebar.

1

Study Guide

* Read the goal and performance indicators to find what is to be learned from package.
* Read the vocabulary list to find knew words that will be used in package.
* Read the introduction and information sheets.
* Complete the job sheet.
* Complete self-assessment.
* Complete post-assessment.

Vocabulary



* Baseplate
* Bearing capacity
* Course aggregate
* Fine aggregate
* Footings
* Grouted
* Pile foundation
* Portland cement
* Raft foundation
* Rebar
* Shims
* Test hole

Introduction

Power plant machinery may weigh many tons or it might be of smaller size. It must be placed on a solid base or foundation that will not settle or vibrate when the equipment is operating.

The underlying soil strata is most important in the design of a foundation. Some extreme examples of foundation problems are found in the permafrost regions of the Arctic and in the swampy regions of the Southeast. Without special foundation footings, it would be the same as placing the machine on a giant mountain of jello. The vibration of the machines would work everything downward. To overcome such problems, piles are driven down to hard rock or solid earth.

This package introduces the basic concepts of foundations for installation of power plant machiney.

Information

The foundation of a power plant is very important. Because of the weight of power plant equipment, it must be placed on solid soil. Any settling or movement of the machinery causes problems in alignment and leads to bigger trouble.

Test Holes

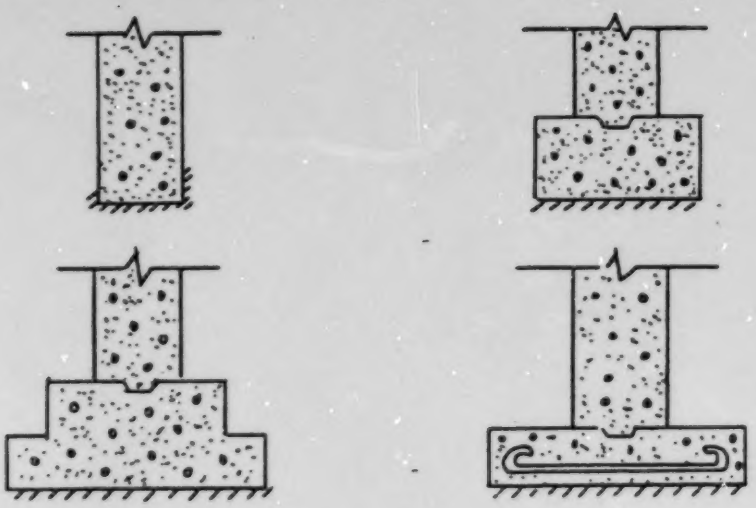
Before erecting a power plant, test holes should be bored deep into the ground. The underlying strata can be checked from the bore samples. A foundation is designed according to the type of strata it is to be placed over. The following values show the bearing capacity of various soils. Bearing capacity is the amount of weight in tons that can be supported by a square yard of soil.

SOIL TYPE	BEARING CAPACITY (TONS)
Hard Rock	160
Hardpan	85 - 105
Hard clay	32 - 42
Fine wet sand	20
Soft clay	10

Foundations -- Footings

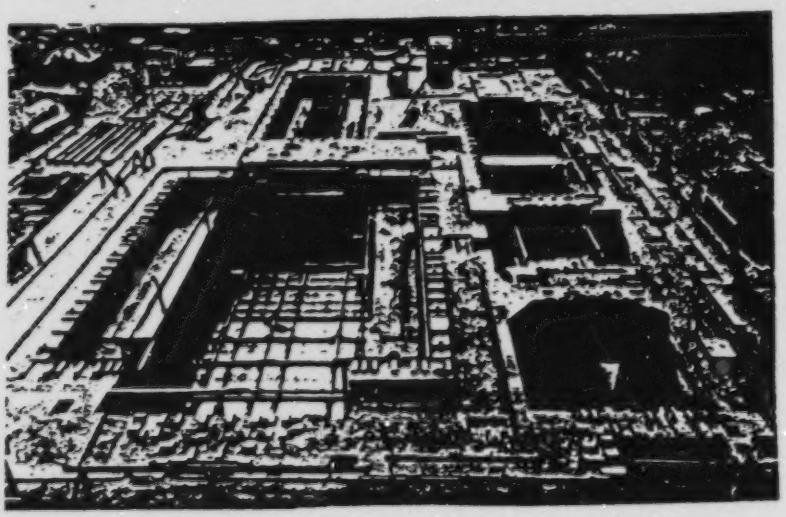
The footings for the foundation wall increase the bearing capacity. If the foundation is to be placed in soft clay, it would require a larger footing. Raft foundations cover the entire ground area with concrete. A pile foundation is made by driving timber, concrete or steel piling deep into the ground. Pile foundations are common in swampy areas and along marine estuaries. Steel piles can be used where the soil is not too corrosive to the steel. Concrete pile can be poured in place or precast and then driven into the ground. A foundation wall and footing are shown on the next page.

Information



Machine Foundations

Large machinery must have a foundation that will absorb the vibrations of the equipment and hold the weight of the machine. Some small machines will have baseplates upon arrival at the plant. In this case the baseplate is leveled with shims and then grouted into the foundation. Grouting is the application of concrete to hold the machine in place.



Information

Large machines are usually dismantled for shipment and rebuilt upon their foundations. Each part of the large machine must be leveled and lined up during this process.

Concrete

A machine foundation should be constructed from high quality concrete. Concrete is a mixture of cement, fine aggregate, course aggregate and water. The fine aggregate is a fine sand. Course aggregate is a crushed stone or washed river gravel that has been graded to size. Portland cement is the most common type used in concrete construction. Water for mixing concrete should be clean and as free of organic matter as possible. Organic matter or silt will prevent the cement from binding to the aggregate, thus causing a weak concrete.

The proportions of a concrete mixture are stated as the ratio of cement to fine aggregate to course aggregate. For example, a 1:3:6 mixture contains one cubic foot of cement; three cubic feet of sand and six cubic feet of gravel. The following mixtures are recommended:

1:3:6 Concrete floors
1:2:5 Machine foundations
1:1:2 Concrete columns and girders

Curing Concrete

Concrete must be allowed to harden and cure before it is subjected to its full load. The water must evaporate from the concrete in order to reach its full strength. Most of the water will evaporate during the first week of curing. After that, the curing process will take place over several years. Freezing and extremely dry temperatures cause premature drying which weakens the concrete. Some protection must be given to concrete to avoid its damage by premature drying.

Reinforcement

The bearing capacity of concrete can be greatly increased by reinforcement. Steel bars are normally used for this purpose. These bars are called rebar or reinforcement bar. They tie the concrete structure together in such a way that the stress is distributed over a large area rather than being on a small portion of the foundation.

The amount of rebar to be used will be determined by the bearing capacity needed. If a large mass is to be installed, the rabar should be spaced closer together.

Assignment

* Complete the job sheet.
* Complete the self-assessment.
* Complete the post-assessment.

Job Sheet

TEST CONCRETE SAMPLES

* Materials needed

  - Portland cement
  - Fine sand
  - Washed gravel (3/4" minus)
  - Wheelbarrow
  - Shovel
  - 3 forms made of 1" x 4" nailed together in 12" square

* Mix and fill one form with a 1:6:12 proportioned concrete mix.

* Mix and fill second form with a 1:1:2 concrete mix.

* Mix and fill third form with a 1:1:2 concrete mix and place welding rods across both ends and down the sides for reinforcement.

* Allow concrete mixtures to cure for one week.

* Hit the concrete squares with a hammer.

* Which ones are easiest to break?

Self Assessment

Match the following terms and phrases.

____	1. Bearing capacity	A.	Fine sand.
____	2. Raft foundation	B.	Washed river gravel.
____	3. Test hole	C.	Concrete application to base-plate of machine to hold it in place.
____	4. Steel piles	D.	The amount of weight in tons that can be supported by a square yard of soil.
____	5. Concrete piles	E.	A hole bored into the earth for core sample to determine bearing capacity.
____	6. Baseplates	F.	Are subject to corrosion in some types of soil.
____	7. Grouting	G.	Used in leveling machines on foundations.
____	8. Shims	H.	Can be precast and driven.
____	9. Course aggregate	I.	Some machines have it attached when they arrive at the installation site.
____	10. Fine aggregate	J.	The entire ground area is covered with concrete.

Self Assessment Answers

D 1.

J 2.

E 3.

F 4.

H 5.

I 6.

C 7.

G 8.

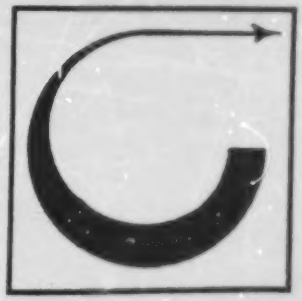
B 9.

A 10.

Post Assessment

1. What is meant by bearing capacity?
2. What is a common type of cement?
3. What does a 1:3:6 concrete mix mean?
4. What is a course aggregate?
5. What is the steel rod or bars that are used to strengthen concrete called?
6. What is a major concern in using steel pile for footings?
7. List two methods of installing concrete pile?
8. What will cause premature drying of concrete?
9. What is a raft foundation?
10. What is a shim used for?

Instructor Post Assessment Answers



1. The tons of weight that will be supported by a square yard of soil.
2. Portland
3. One part cement, three parts fine aggregate and six parts course aggregate.
4. Crushed stone or washed gravel
5. Rebar
6. Corrosion of steel by the soil
7. Precast and driving; pouring in place
8. Freezing temperatures or dry atmospheric conditions
9. One that covers the total ground area
10. To level equipment on its foundation

Supplementary References

* Correspondence Course. Lecture 10. First Class, Section 3. Southern Alberta Institute of Technology. Calgary, Alberta, Canada.

INSTRUCTIONAL LEARNING SYSTEMS

22.2

INSTALLATION — ALIGNMENT

Goal:

The apprentice will be able to describe alignment of newly installed equipment.

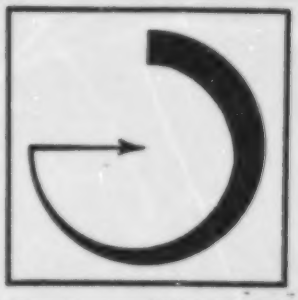
Performance Indicators:

1. Describe small machine alignment.
2. Describe turbine alignment.
3. Describe shaft coupling alignment.

Study Guide

* Read the goal and performance indicators to find what is to be learned from package.
* Read the vocabulary list to find new words that will be used in package.
* Read the introduction and information sheets.
* Complete the job sheet.
* Complete self-assessment.
* Complete post-assessment.

Vocabulary



* Driven
* Driver
* Flexible coupling
* Feeder gauge
* Pin gauge
* Rigid coupling
* Spirit level
* Stretched wire method

Introduction

Once equipment is set down on the foundation, a problem of "lining up" must take place. A turbine must be connected to its generator in a line or the shaft will be stressed.

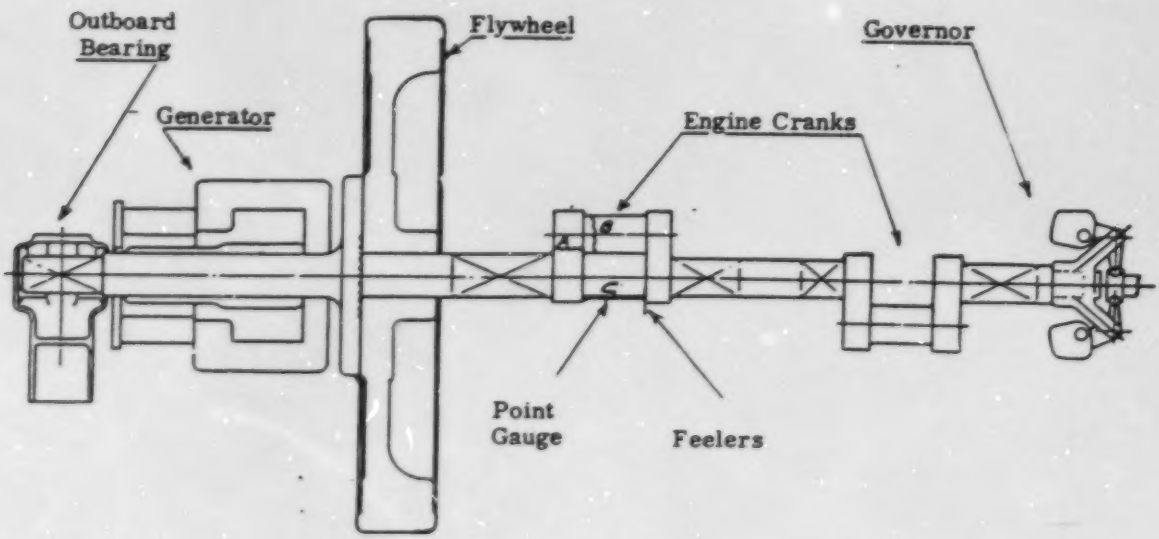
One method of "lining up" is to line up the bearings. Another type of lining up is accomplished at the shaft couplings where the two machines link together. This package gives a brief overview of alignment. In most cases, experienced installers will be lining up the equipment at new installations. The material in this package is intended to give the apprentice a general knowledge of the alignment procedures.

Information

When equipment is installed on a foundation, it must be properly aligned. If not properly aligned, there will be a stress on the crankshaft that will cause bending and breakage. The steam engine must be lined up with its generator. Compressors must be lined up with the driving motor. The engine is the driver and its generator is the driven machine. Alignment is the proper lining up of the driver and driven machines

Small Machine Alignment

* Set engine on bedplate, level, bolt down and check alignment of crankshaft.
* Match up coupling faces on engine crankshaft and generator. Use a feeler-gauge to determine if the two coupling faces are parallel.
* Bolt the couplings together.
* Remove temporary supports from flywheel and rotor.
* Use shims to line up the generator with the engine.

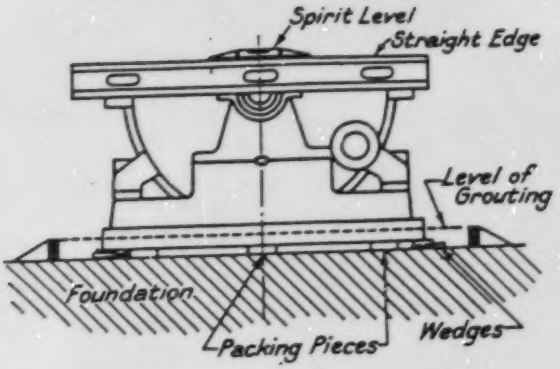


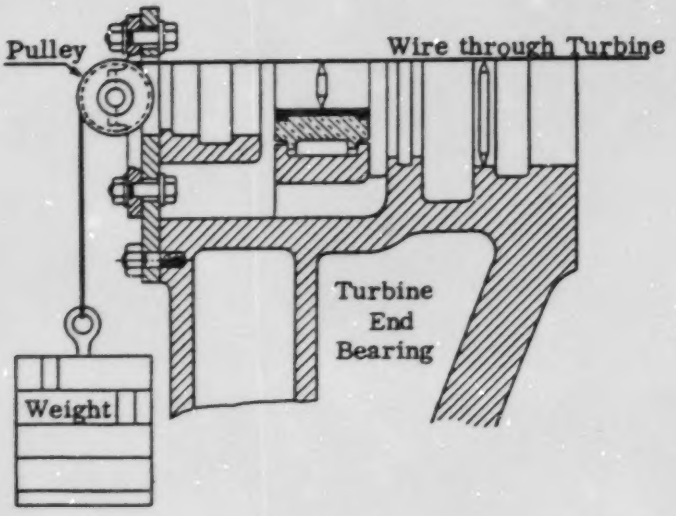
Turbine Alignment

Foundations for large turbines must be reinforced concrete. Separate foundation blocks are poured for the turbine and alternator. The machine center line is determined and holes are drilled for hold-down bolts. The holes are drilled in steel girders that tie the two foundation blocks together. The bedplate is

Information

fastened to the foundation and leveled with steel wedges. A spirit level is used to determine when the bedplate is level. The bottom half of the turbine cylinder is installed along with the bedplate. Bearing alignment can be checked by the stretched wire method. The shafts are removed and a wire is stretched between the end bearings and weighted to hold it tightly in place. Intermediate bearings can be checked for their relationship with the wire line. Adjustments can be made until all bearings are lined up. Pin gauges and feeler gauges are needed to measure for alignment. The following diagrams show how a spirit level is used to level the turbine and the stretched wire method of aligning bearings.





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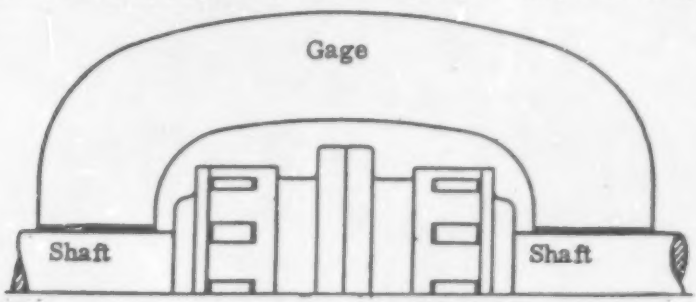
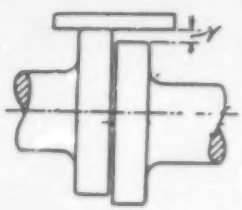
Information

Shaft Coupling Alignment

Shaft coupling alignment will differ between rigid type couplings and flexible type couplings. Manufacturers provide directions for aligning couplings of specific machines. Measurements are the most used method for checking alignment. Some manufacturers supply a coupling gauge.



A simple straight edge will show if the couplings are out of line. Readings must be made at 180 from each other. The straight edge method of measurement is shown.



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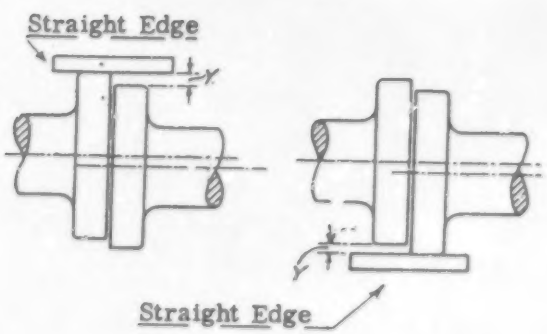


Assignment

* Read pages 15 - 25 in supplementary reference.
* Complete the job sheet.
* Complete the self-assessment and check answers.
* Complete the post-assessment and have instructor check answers.

Job Sheet

MEASURE SHAFT COUPLINGS FOR ALIGNMENT

* Use a straight edge to measure across the couplings where two shafts are linked.
* Measure both top and bottom.
* Are the couplings lined up?
* If a manufacturer's coupling gauge is available, use it to measure shaft couplings for alignment.
* Determine which way the machines need to be moved for lining up the couplings.

Self Assessment

1. What is a driver?

2. What is a driven machine?

3. Which tool is used to determine if a bedplate is level?

4. Which alignment method is used to line up bearings?

5. List two types of couplings.

Self Assessment Answers

1. An engine that supplies the power.

2. A machine that is turned by the power of the driver.

3. Spirit level.

4. Stretched wire method.

5. Flexible and rigid.

Post Assessment

Match the following terms and phrases.

____	1. Driver	A. Used to measure alignment of couplings.
____	2. Driven	B. Used to measure alignment of bearings.
____	3. Stretched wire method	C. Used to measure level of bedplate.
____	4. Straight edge method	D. A machine that is powered by another machine.
____	5. Spirit level	E. A machine that provides the power.

Instructor Post Assessment Answers

E 1.

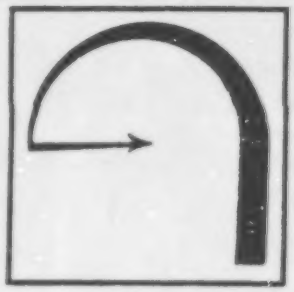
D 2.

B 3.

A 4.

C 5.

Supplementary References



* Correspondence Course. Lecture 10, Section 3, First Class.
Southern Alberta Institute of Technology. Calgary, Alberta, Canada.

23.1

TRADE TERMS

Goal:

The apprentice will be able to define common trade terms used in steam plants.

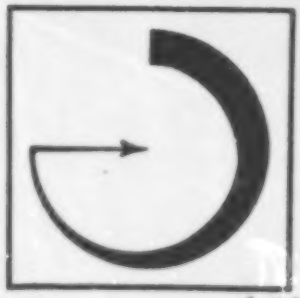
Performance Indicators:

1. Explain meaning of 25 common trade terms.
2. Use trade terms in conversation with others.

Study Guide

* Read the goal and performance indicators to find what is to be learned from package.
* Read the vocabulary list to find new words that will be used in package.
* Read the introduction and information sheets.
* Complete the job sheet.
* Complete self-assessment.
* Complete post-assessment.

Vocabulary



* Blow-off
* Boiling out
* Cavitation
* Dry saturated steam
* Dryback boiler
* Embrittlement
* Feedwater
* Fireside
* Flame-out
* Foaming
* Gland
* Incomplete combustion
* Packaged boiler
* Paralleling
* Perfect combustion
* Priming
* Purging
* Refractory
* Saturated steam
* Steam trap
* Superheated steam
* Water hammer
* Water leg
* Wetback boiler
* Wet steam

Introduction

Trade terms are descriptive words that are used within a trade. Each trade or occupation uses trade terms that are only understood by others in their trade. These words are different from the standard technical terms which may be used across many occupational lines. Basically, trade terms are nicknames that the industry has placed on tools and processes that are unique to the trade.

Apprentices must learn the trade terms as quickly as possible. Without this knowledge, technical oriented conversations will go over their heads. This package is not a complete listing of trade terms. The apprentice is urged to learn about the 25 trade terms of this package and continue to add to the trade vocabulary. It is a good starter list for those that are entering a new field. Beyond that point, the apprentice should expand their use of trade terms into several hundred. The trade terms must be mastered in any trade entered.

Information

* Blow-off is the removal of sludge and solid material through blow-off connections and valves. Continuous blow-off removes heavily concentrated water from the boiler.

* Boiling out is a process by which the waterside of a new boiler is cleaned of oil, grease and other contaminants. Chemicals are used in the boil-out.

* Cavitation is a condition that occurs when the net positive suction head of a system is reduced below the NPSH of the pump. Small vapor bubbles form in the liquid and collapse, causing erosion of the propeller.

* Dry saturated steam is a saturated steam without suspended water particles. Saturated steam is steam at the temperature of saturation which is 100 C at atmospheric pressure.

* Embrittlement is a form of metal cracking that can cause boiler failure. Embrittlement usually occurs under conditions where high concentrations of caustic solutions exist.

* Feedwater is water that is fed into the boiler for the production of steam.

* Fireside refers to the furnace side of the boiler.

* Flame-out is a condition that occurs when the main burner flame fails. Sometimes it is blown out by excess air supply.

* Foaming is a condition where large amounts of bubbles form in the drum. It causes water to be carried to the turbine along with the steam.

* Gland is a pump part that holds the packing for preventing leaks.

* Incomplete combustion is a condition where all combustibles are not burned and some pass out the stack with the gases.

* Packaged boiler is a boiler that comes from the manufacturer with all of its accessories attached.

* Paralleling is a term used to describe the hooking together of two or more units to do a common job. Pumps, compressors or turbines may be paralleled.

* Perfect Combustion is combustion in which all combustibles are completely burned leaving carbon dioxide, sulphur dioxide, water, nitrogen and ash as the products of combustion.

Information

* Priming refers to water being carried over in steam. It is caused by too high water level, foaming or overloading.

* Purging is the removal of combustible gases from a furnace by passing a flow of air through it.

* Refractory means that a refractory material is used in its construction. A brick lined furnace is an example of a refractory.

* Saturated steam is steam at the temperature of saturation which is 100 C at atmospheric pressures. This temperature will vary with pressure.

* Steam traps are special devices that are designed to remove water from the steam.

* Superheated steam is steam that has been heated beyond the temperature of saturation.

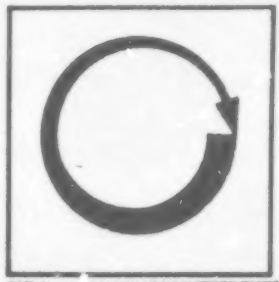
* Water hammer is a condition in pipes that causes violent shock waves. It can be caused by turning on valves too quickly.

* Water leg is a water filled chamber that surrounds a furnace so that heat transfer can be effected.

* Wetback boiler is a boiler that has a waterleg surrounding the rear chamber instead of refractory materials.

* Wet steam is steam that has suspended water particles in it.

Assignment



* Complete the job sheet.
* Complete the self-assessment.
* Complete the post-assessment.

Job Sheet

DEVELOP OWN LIST OF TRADE TERMS

* When a new trade term is heard, write it down.

* Find out the meaning of the word by asking an experienced person—"What does it mean?"

* Build your own dictionary of trade terms.

Self Assessment

Match terms with their descriptive phrases.

_____	1. Priming	A. Cleaning combustible gases from boiler by flow of air.
_____	2. Purging	B. Main burner is snuffed out.
_____	3. Blow-off	C. Passing water into the turbine through steam.
_____	4. Flame-out	D. Steam with suspended water particles.
_____	5. Wet steam	E. Removal of sludge from boiler through connections.

Self Assessment Answers

C 1.

A 2.

E 3.

B 4.

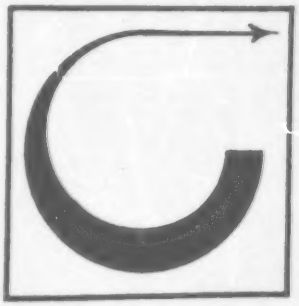
D 5.

Post Assessment

Match terms and descriptive phrases.

_____	1. Dryback boiler	A. Boiler that comes from manufacturer with all fittings attached.
_____	2. Steam trap	B. Boiler with waterleg for heat transfer.
_____	3. Wetback boiler	C. Furnace side of the boiler.
_____	4. Packaged boiler	D. Device for removing water from steam.
_____	5. Fireside	E. Boiler with bricklined rear chamber.

Instructor Post Assessment Answers



E 1.

D 2.

B 3.

A 4.

C 5.

Supplementary References

* Experienced people during their conversations.
* Trade literature.